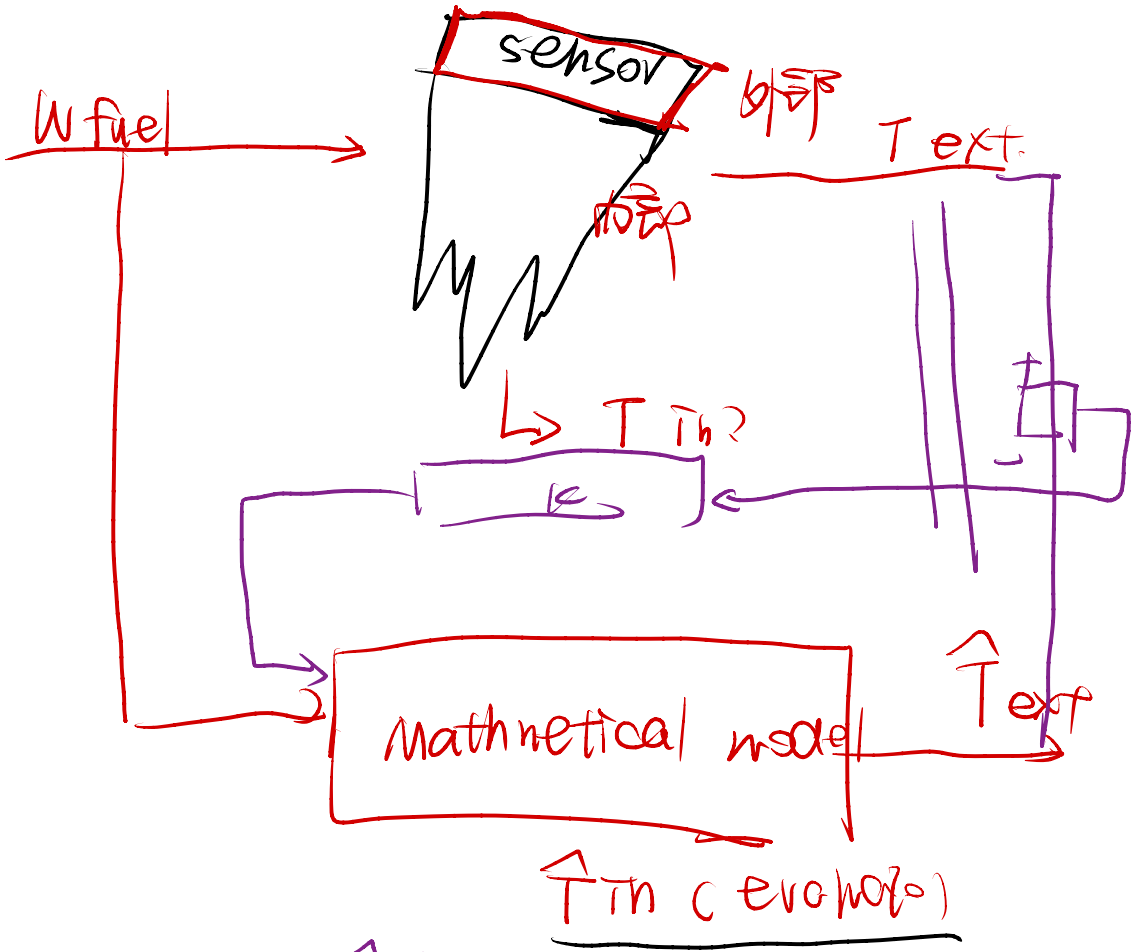
kalman filter

优化控制

Example



Minimize $|\hat{T}_{ext} - \hat{T}|$ controller K

Detailed part

$\dot{x}$ ⇒ speed

$x_{t+1} = Ax_t + u$ 以下动力

$u \sim N(0, P)$

$u \sim N(0, P)$ 高斯噪音

$y_t = Hx_t + v$

$v \sim N(0, Q)$

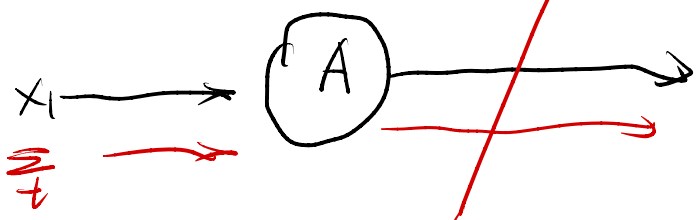
$$\begin{bmatrix} x_{t+1} \\ \dot{x}_{t+1} \end{bmatrix} = \begin{bmatrix} 1 & \Delta t \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x_t \\ \dot{x}_t \end{bmatrix}$$

$H = [1 \; 0]$

Predict $x_1 \in (0.8, 1)$

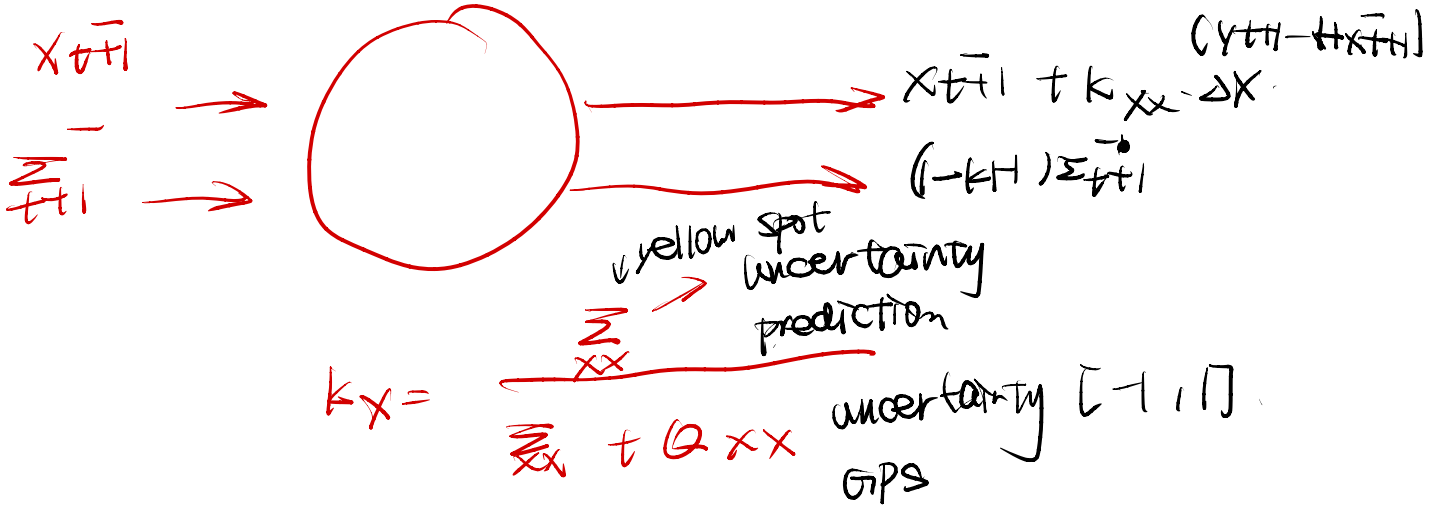
$\dot{x}_1 < 60$

prediction step



Not find estimate

update step



$\dot{x}_{t+1}^{+} = \dot{x}_{t+1}^{-} + K\dot{x}\,\Delta X$ $\quad K\dot{x} = \dfrac{\Sigma_{x\cdot\dot{x}}}{\Sigma_{xx} + Q_{xx}}$

Independent ⇒ useless

① measurement situation function

estimate of current $\hat{x}_k$ = predicted of current $\hat{x}_k$ + $K_k(z_k - H_k\hat{x}_k)$

K_k ↓ Factor

Predicted of current → 实际 measurement

③ predict state

$\hat{x}_k = F_k \hat{x}_{k-1} + B_k u_k$

F_k ↓ 动态化

$B_k u_k$ ↓ control by u_k ↓ 外部影响

③ covariance prediction

$P_k = F_k P_{k-1} F_k^T + Q_k$

Initial one

P_{k-1} 状态矩阵

Q_k 协方差矩阵 (外部原因不确定性)

$\mathrm{cov}(x_i \cdot x_j) = \frac{1}{m-1}\sum_{k=1}^{m}(x_{ik} - \bar{x}_i)(x_{jk} - \bar{x}_j)$

④ K_{xx}

$K_k = P_k H_k^T (H_k P_k H_k^T + R_k)^{-1}$

R_k ↓ 测量噪声

state estimation uncertainty $= \dfrac{P_k H_k^T}{H_k P_k H_k^T + R_k}$ → measurement uncertainty

5. State update

$$P_k = (I - K_k H_k) P_k$$

Extended kalman Filter (EKF)

Quite same non-linear

1. Prediction step:

state

$\hat{x}_k = f(x_{k-1}, u_k)$ 非线性

covariance:

$$P_k = F_k P_{k-1} F_k^T + Q_k$$

2. Measurement update

M P

$z_k = h(\hat{x}_k)$

kalman Gain

$$K_k = P_k H_k^T (H_k P_k H_k^T + R_k)^{-1}$$

State Update

$$\hat{x}_k = \hat{x}_k + K_k (z_k - h(\hat{x}_k))$$

Covariance Update

$$P_k = (I - K_k H_k) P_k$$